HABITAT DISTRUBUTION, HABITAT CHARACTERISTICS AND BEHAVIOUR OF THE BLACK GIANT SQUIRREL (*Ratufa bicolor penangensis*) IN PENANG ISLAND

by

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TABLE OF CONTENTS

Page

LIST OF TABLES

Page

LIST OF FIGURES

Page

TABURAN HABITAT, CIRI-CIRI HABITAT DAN PERLAKUAN TUPAI KERAWAK HITAM (*Ratufa bicolor penangensis*) DI PULAU PINANG

ABSTRAK

Tupai Kerawak Hitam (*Ratufa bicolor penangensis*) disenaraikan sebagai haiwan yang dilindungi sepenuhnya oleh Akta Perlindungan Hidupan Liar Malaysia (2010) dan haiwan yang dilindungi di bawah undang-undang antarabangsa seperti IUCN disebabkan kemusnahan habitatnya. Penyelidikan tentang taburan, pemilihan habitat, pergerakan dan perlakuan seharian Tupai Kerawak Hitam yang dijalankan di Pulau Pinang, dari Januari 2008 sehingga Oktober 2009, bertujuan untuk mengkaji maklumat asas mengenai spesies ini. Penyelidikan tentang taburan sarang dan kriteria habitat seperti latitud, longitud, ketinggian pokok dari paras laut, tinggi pokok dan ukur lilit pokok (GBH) dijalankan. Peta tata guna tanah dibuat untuk menganalisa corak taburan sarang dengan menggunakan penderiaan jauh dan Sistem Maklumat Geografi (GIS). Berdasarkan bacaan dari aras laut, tupai ini ditemui di dua jenis habitat iaitu kawasan tanah tinggi dan kawasan tanah rendah. Di kedua-dua habitat tersebut, tupai ini bertaburan di beberapa jenis lokasi seperti hutan tanah rendah, hutan tanah tinggi, hutan pantai dan kawasan rekreasi. Data kriteria habitat seperti jarak ke makanan, jalan dan bangunan diukur menggunakan GIS. Semua data ini dievaluasi menggunakan ujian *Principal Component Analysis (PCA)*. Data pergerakan dan perlakuan harian dicatat secara terus. Data pergerakkan Tupai Kerawak Hitam dicatat menggunakan pencatat laluan GPS bermula dari ia memulakan aktiviti sehingga tamat aktiviti untuk tujuh hari berturut-turut. Analisis PCA menunjukkan, pemilihan habitat tupai ini dipengaruhi oleh faktor-faktor utama seperti tinggi pokok, jarak dengan makanan dan jarak dengan bangunan. Faktor lain yang mempengaruhi pemilihan habitat pula ialah jarak dengan jalan atau susur hutan dan ukur lilit pokok yang digunakan untuk bersarang. Corak pergerakannya di empat lokasi berbeza menunjukkan jumlah bacaan waktu aktif yang sama dengan julat bacaan antara 11.87 hingga 12.12 jam setiap hari manakala jumlah pergerakan menunjukan bacaan yang berbeza dengan julat di antara 493.20 hingga 1158.67 meter setiap hari. Setiap hari, tupai ini mengisi masanya dengan aktiviti utama iaitu berehat (44%) dan makan (41%), diikuti dengan pergerakkan (7%). Sedikit masa sahaja digunakan untuk mencari makanan (4%) dan perlakuan sosial lain (4%) daripada jumlah waktu aktif.

HABITAT DISTRUBUTION, HABITAT CHARACTERISTICS AND BEHAVIOUR OF THE BLACK GIANT SQUIRREL (*Ratufa bicolor penangensis*) IN PENANG ISLAND

ABSTRACT

The Black Giant Squirrel (*Ratufa bicolor penangensis)* is listed as a totally protected species under the Malaysian Wildlife Conservation of Act (2010) and classified as protected species under the international law such as IUCN by the loss of its habitat. A study on the Black Giant Squirrel's distribution, habitat selection, daily movement and behaviour was conducted in Penang Island, from January 2008 to October 2009, to obtain baseline information for the species. Surveys on habitat distribution and habitat characteristics such as latitude, longitude, elevation, tree height, and Girth at Breast Height (GBH) were measured and recorded. Land use map was generated to analyse the squirrel's habitat locations by using remote sensing and Geographic Information System (GIS). Based on elevation, this species was found to be relatively common in two habitat types; hill land and lowland areas. Within both habitat types, this squirrel is distributed in several locations such as in lowland forest, hill forest, coastal forest and recreation areas. Habitat characteristics data such as the distances of the nests to food, to road, and to building were calculated by using GIS and evaluated with Principal Component Analysis (PCA). Data on movement pattern and behaviour were collected using direct sampling. The movement patterns of the Black Giant Squirrel were recorded using GPS track recorder from the moment they start their activities until the end of their activity every day for seven continuous days. PCA analysis showed that, habitat selection is influenced by several major factors such as height of nesting trees, distance from food supply (feeding tree) and distance from building. Other factors that influenced habitat selection are distance from road or forest trail and GBH of nesting tree. Movement pattern analysis at four different locations indicated that, total active period range between 11.87 to 12.12 hours per day, while total distance traveled recorded was within the range of 493.20 to 1158.67 meters per day. Daily, this squirrel spent most of their time resting (44%) and feeding (41%), followed by ranging (7%). Less time is spent for foraging and social and self-directed behaviour (4% each) from their total active period.

CHAPTER ONE
INTRODUCTION

1.1 General introduction

Malaysia's tropical rainforest provide a large habitat for a rich diversity of flora and fauna species. However, deforestation towards economic and human development such as agriculture, and urbanization have resulted in mass clearing of biodiversity in Malaysia (Dolman, 2000). The situation is critical because, each species of organism especially animals need a very specific habitat to match with their life requirements. Habitat selection of animals is proximately determined by necessary resources, such as food and safe roosting sites, which are required for their daily activities. Ultimately, habitat selection aims at improving the survival of individuals and enhancing their reproductive success by providing food, mates and potential nesting sites (Kumar *et al.*, 2007).

The Black Giant Squirrel (*R.bicolor*) is listed as Near Threatened under the International Union for Conservation of Nature (IUCN) Red List 2007 (IUCN, 2008) and as a totally protected species under the Malaysian Wildlife Conservation of Act 2010 (Malaysian Wildlife Conservation of Act, 2010). Globally, *R.bicolor* is listed as Threatened species because this species has declined significantly (but at a rate less than 30% over ten years or three generations) as an effect of being over harvested for food, and because of widespread habitat loss through much of it range, making this species close to qualifying for Vulnerable status (IUCN, 2008). In Malaysia, *R.bicolor* is listed as totally protected species under the Malaysian Ptotection Wildlife of Act, 2010 because it is now extremely rare, due to hunting and habitat destruction (Malaysian Wildlife Conservation of Act, 2010; DWNP, 2008a).

Both acts show that deforestation and hunting were the major threats that influenced the abundance of *R.bicolor*. The destruction of their habitat had been fatal for this animal because it is difficult for them to find the right food. *R.bicolor* is hunted almost throughout their distributional range in Malaysia, although the severity of hunting varies with the protection status. The most common hunting techniques is the use of the dagger-type metal instrument tied to a long bamboo stick, which is used to pierce *R.bicolor*. The animal is either killed or if the injured animal jump from the nest and fall to the ground, it is captured by trained hunting dogs (Rahim, personal communication).

To avoid global extinction, it is necessary to first obtain a better understanding of *R.bicolor*, because, management and conservation plans can be successful only with adequate scientific knowledge about the species. More information, such as habitat selection, ecology and behavior are also needed. Habitat selection can be considered as a hierarchical and scale-dependent process. In terms of individual fitness, habitat selection at home range scale is likely to be more important than local or regional scale decisions because the survival of individuals and their reproductive success is obviously dependent on resources in the vicinity of the nesting site (Cody, 1985).

However, identification of key habitat components and minimum requirements of the species is often difficult to perform and presumes good knowledge of the species under consideration. More efforts are needed in identification and detailed research process of endangered and threatened animal species that live in the forest as an effort to conserve the species and their habitat.

All the data can contribute to a better understanding of *R.bicolor* habitat selection and behavior and, thus, enhance better management and conservation plan.

1.2 Rationale

In Malaysia, there is no detailed field studies carried out in the wild on *R.bicolor*. Only Chasen (1940), Hill (1960), Harrison (1966), Langham (1977), Medway (1983), Baillie (1996a), Charles (2001) and Hill (2007) noted with general information on their distribution and behaviour. *R.bicolor* is found only in South-east Asia, and has declined considerably in many areas due to loss and fragmentation of tall forest as well as hunting (Charles, 2001).

The primary objective of this study was to obtain baseline information *R.bicolor* in Penang Island. The study of *R.bicolor* habitat requirements will provide us with the habitat selection patterns selected by this species.

Information on morphology, distribution, reproduction, diet, home range, and nesting behavior of *R.bicolor* are vital information which is needed to understand this species before any effort in trying to conserve them and their habitats are to be enforced. Understanding the spatial distribution and movement that a certain species makes within its habitat is important for interpreting ecological processes. Later, all this informations plays a vital role in formulating conservation management plans.

In view of the fact that most vertebrate species depend on rainforest and that most of the world's rain forests has been reduced to disturbed and fragmented

patches, the abilities of animals to survive in such areas are also of great importance in formulating conservation strategies (Umapathy and Kumar, 2000; Holmes and Drickamer, 2001; Taulman and Smith, 2003; Steimentz *et al*., 2006; Kumar *et al*., 2007).

On the whole, all the data collected during this study provide an information for finding potential habitat and forest types for *R.bicolor* not only on Penang Island but at other places in the country.

1.3 Research objectives

The objectives of this study were to study habitat distribution, as well as to understand the habitat requirements and behavior of the endangered *R.bicolor* in Penang Island. This information later will be used for the conservation and better management of *R.bicolor* not only in Penang Island, but elsewhere in Malaysia. Thus, the study objectives can be divided into two main parts as mentioned below:

1) To investigate the habitat distribution and requirements of *R.bicolor* in Penang Island with specific emphasis on determining the following:
    a) To determine habitat types and the current distribution of *R.bicolor* in Penang Island using direct sampling and mapping.
    b) To determine habitat requirement and important variables that might influence the habitat selection of *R.bicolor* in Penang Island by analyzing all nesting site characteristics parameters using the multivariate statistical analysis (PCA).

2) To investigate the ecology of *R.bicolor* in Penang Island by determining the following:

    a) To establish daily movement activities and patterns made by *R.bicolor* using direct sampling and Global Positioning System (GPS).

    b) To examine the behaviour of *R.bicolor* using direct sampling. Time percentages of each activity will be measured in order to study their behavior and daily activities. Their activities will be grouped into four activities which were feeding, foraging, resting and ranging.

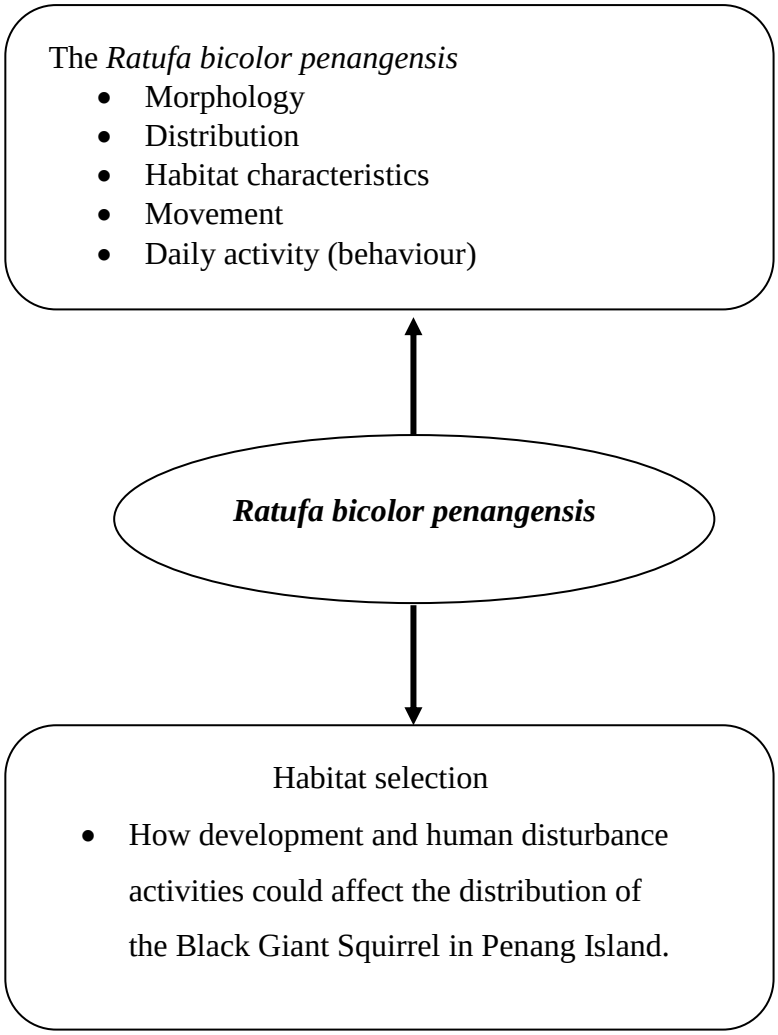

Figure 1.1: A framework for the current study

1.4 Thesis overview

Chapter 1 consist the general introduction, rationale and objectives of this research.

Chapter 2 presents literature review related on this research. It consists of the previous studies conducted on *R.bicolor,* previous studies conducted on flora and fauna in Penang Island, environmental problems in Penang Island that could have an effect the distribution of *R.bicolor*, and conservation plans for *R.bicolor.*

Chapter 3 describes the study area that occupied along this research. It consists of the descriptions of study area (climate, topography and habitat types) and location, description and selection of main research area.

Chapter 4 describes and discusses on the physical characteristics and distribution of *R.bicolor*. Earlier, this chapter will describe the physical characteristics (body structure, weight as well as skin and fur color) of *R.bicolor*. Then, follow by results on distribution of *R.bicolor* in Malaysia and distribution *R.bicolor penangensis* in Penang Island. Available data/information were used to study the distribution of *R.bicolor* in Malaysia while field survey, global positioning system (GPS), geographic information system (GIS) and remote sensing methods were used to investigate *R.bicolor penangensis* distribution pattern in Penang Island.

Chapter 5 presents the result and discussion on habitat selections of *R.bicolor penangensis* in Penang Island. It consists of nesting site characteristics (topography

and habitat types, food resources and forest structure) that occupied by *R.bicolor penangensis.*

Chapter 6 present and discuss on the behaviour and movement activities of *R.bicolor penangensis* in Penang Island. This chapter will describe detail information on the *R.bicolor penangensis* daily activities and estimation on their daily movement.

Chapter 7 presents the conclusion and recommendation for further studies and conservation of *R.bicolor*.

CHAPTER TWO

LITERATURE REVIEW

2.1 Distribution of the Black Giant Squirrel (*Ratufa bicolor*)

Based on available information, the *R.bicolor* is found in Northeast India, Bhutan, north Bangladesh, through Myanmar, Thailand and South China, into Indonesia, up to Vietnam. In India, *R.bicolor* is distributed at Assam, Arunachal Pradesh, Manipur, Megahalaya, Mizoram, Naga Island, Sikkim, Tripura and West Bengal (Srinivasulu *et al*., 2005).

In Vietnam, *R.bicolor* can be found in several national parks and nature reserves such as Bach Ma National Park (Thinh *et al.*,2002), Ca Ba National Park (Johns, 2007), Bac Huong Hoa Nature Reserve (Hanoi, 2008), and Hoang Lien-Van Ban Nature Reserve (Dat, 2009) . Apart from that, *R.bicolor* is also distributed at Ta Nung Valley (Myres, 2006), Mt. Tay Con Linh (Lunde *et al.*, 2008). The appearance of *R.bicolor* in other places beside national park and nature reserve are unknown due to the lack of available data.

In Laos, *R.bicolor* can be found in south and central of Laos (Eran *et al.*, 2000; and Timmins and Ducworth, 2008). It can also be found at Khammouan Limestone National Biodiversity Conservation Area (Timmins, 1997)

As in Vietnam and Laos, *R.bicolor* recorded in Cambodia was almost the same, only recorded in Wildlife Sanctuary and National Park. In Cambodia, previous studies listed *R.bicolor* at three locations which are Phnom Pricy Wildlife Sanctuary (Timmins and Ratanak, 2001), Kravanh Range of Southeastern Combodia (Boonratana, 1999) and Con Dao National Park (Ringer and Robinson, 1999).

The population of *R.bicolor* in Myanmar and China are poorly documented. Only one location has been recorded in each country. In Myanmar, *R.bicolor* only reported in Southern Rakline Yoma (Geissmann *et al.*, 2008). For China, it is found in Bawangling National Nature Reserve (Bosco *et al.*, 2005). Myanmar and China face serious deforestation issue, which caused most of *R.bicolor* natural habitat loss.

Myanmar recorded one of the highest deforestation rates in the world, Myanmar's forests have been under assault for decades. Between 1990 and 2005 the country lost 18% of its total forests to logging, agriculture, and fuel wood collection (Xin, 2007). In China, illegal logging and burnt agricultures consumed up to 5,000km^2 of virgin forest every year. In northern and central China, forest cover had been reduced by half in the last two decades. The mountains in southwest China have suffered serious deforestation, logging, hunting and collection of plants and animals for traditional medicines (Jeffrey, 2008).

In Indonesia, this squirrel can be found in Sulawesi (Lance *et al.*, 2008) and Gunung Pulung National Park (Lamnertink *et al.*, 2009). In Thailand, *R.bicolor* can be found in three national parks with is Kaho Phra Thaeo National Park, Hat Khanom Mu Ko Thale Tai National Park and Khao Yai National Park (Robson,

2004). Apart from that, *R.bicolor* also can be found in Montane Evergreen Forest located at Northern Thailand (Pattanavibool and Dearden, 2002) and Khao Nor Chuchi (Robson, 2004). As in other countries, records on R.bicolor have only been conducted in protected areas (national park and forest reserve). Further studies on *R.bicolor* are needed as a plan for conservation activities. The distribution of *R.bicolor* in Malaysia will be discussed in Chapter four.

Subspecies differentiation of *R.bicolor* used to be determined by their pelage characteristics (Li *et al.,* 2002). Available information on *R.bicolor* distribution in South-east Asia was compiled through secondary information such as books, internets articles, reports, photographs and research articles. All the information includes subspecies names, body descriptions and location where each *R.bicolor* subspecies was found. In some cases, verifications were impossible due to the lack of resources and accessibility to the information. All the information on distribution of *R.bicolor* were documented and compiled accordingly based on *R.bicolor* subspecies distribution.

Based on previous studies, a total of twenty subspecies of *R.bicolor* was recorded in South-east Asia (Table 2.1). Additionally, available information on morphology description and location of *R.bicolor* found in South-East Asia were also presented (Appendix Table 3.0).

Highest numbers of *R.bicolor* subspecies recorded in Thailand with nine subspecies present, followed by Indonesia with seven subspecies, Malaysia with four subspecies and China with three subspecies. Meanwhile only one subspecies of

R.bicolor recorded in Laos, Burma and Cambodia (Table 2.1). Although each country recorded different name, body description and location of each *R.bicolor* subspecies, five subspecies shows same recorded. These five subspecies (*Ratufa bicolor peninsulae, Ratufa bicolor fretensis, Ratufa bicolor angusticeps, Ratufa bicolor hainana* and *Ratufa bicolor leucogency*) share their distribution with other countries.

Table 2.1 clearly shows that, only four subspecies of *R.bicolor* occur in Malaysia, which are *R.bicolor peninsulae, R.bicolor fretensis, R.bicolor tiomanensis* and *R.bicolor penangensis*. All these subspecies only occur in Peninsular Malaysia. *R.bicolor peninsulae* can be found at mainland of peninsular Malaysia while other three subspecies found in Tioman Island, Langkawi Island and Penang Island.

Table 2.1: Detail of the *R.bicolor* subspecies name and localities.

No	Subspecies name	Location
1	*Ratufa bicolor bicolor*	-West Java, Indonesia
2.	*Ratufa bicolor albiceps* *Ratufa bicolor baliensis*	-East Java, Bali, Indonesia
3.	*Ratufa bicolor bicolor X albiceps*	-West Java, Middle Java, Indonesia
4.	*Ratufa bicolor peninsulae*	-Peninsular Siam, Thailand -Peninsular Malaysia
5.	*Ratufa bicolor phaeopepla*	-Peninsular Siam, Thailand
6.	*Ratufa bicolor melanopepla*	-Telibon Island in Trang, west of the Peninsular of Thailand
7.	*Ratufa bicolor fretensis*	-Taruteo Island, Thailand -Pulau Langkawi Peninsular Malaysia
8.	*Ratufa bicolor penangensis*	-Penang Island Peninsular Malaysia
9.	*Ratufa bicolor dicolorata*	-Peninsular Siam, Thailand
10.	*Ratufa bicolor tiomanensis*	-Tioman Island Peninsular Malaysia
11.	*Ratufa bicolor condorensis*	-China
12.	*Ratufa bicolor palliate*	-East Sumatra, Indonesia
13.	*Ratufa bicolor laenata*	-West Sumatra, Indonesia
14.	*Ratufa bicolor batuana*	-West Sumatra, Indonesia
15.	*Ratufa bicolor angusticeps*	-China -Java, Indonesia
16.	*Ratufa bicolor anambae*	-South China
17	*Ratufa bicolor hainana*	-Northern Thailand -Hainan, southern china. -Laos. -Northern Burma
18	*Ratufa bicolor leucogency*	-Central and Southeastern Thailand - Cambodia
19	*Ratufa bicolor sinus*	Koh Kut Island off the coast of Southeastern Thailand near the Cambodia border
20.	*Ratufa bicolor decolorata*	The island of Koh Phangngan and Koh Samui, the gulf of Thailand

Sources: Chasen (1940), Hill (1960) and Lekagul and McNeely (1988).

2.2 Previous studies conducted on the Black Giant Squirrel (*Ratufa bicolor*).

In Malaysia, there are no detailed field studies carried out in the wild on the *R.bicolor*. Only Chasen (1940), Hill (1960), Harrison (1966), Langham (1977), Medway (1983), Baillie (1996a), Charles (2001) and Hill (2007) noted general information about their distribution and behaviour. These squirrels are only found in South-East Asia, and have declined considerably in many areas due to loss and fragmentation of tall forest as well as to hunting (Charles, 2001).

Among all the studies mentioned above, only Langham (1977) extensively focused his study on mammals found in Penang Island but only in short note. Chasen (1940), Hill (1960), and Baillie (1996a) concentrated more on explaining distributions and morphology pattern of *R.bicolor* in Malaysia, Sumatra, Borneo and Java.

Apart from the studies mentioned above, there are other short-termed studies that have been conducted on *R.bicolor* in other countries, such as Lekagul and McNelly (1988) and by Datta and Goyal (2008). Lekagul and McNelly (1988) reported the histories, diagnosis, sizes, distribution, description, ecology and behavior on each subspecies of *R.bicolor* found in Thailand. Datta and Goyal (2008) studied the responses of *R.bicolor* to selective logging in western Arunachal Pradesh, India.

Although there are no specifically detailed studies carried out on the distribution of *R.bicolor* in Malaysia, several observation have been recorded on their nesting location by groups of researchers during their fauna survey around

Malaysia, such as at Ulu Endau in Johor (Davison and Heang, 1987), Pasoh Forest Reserve in Negeri Sembilan (Kemper, 1988), Sungai Singgor Area Temenggor Forest Reserve in Perak (Ratnam *et al*, 1995), Tasik Chini Nature Reserve in Pahang (Lim et al, 1999), northern part of Belum Forest Reserve in Perak (Norsham *et al.*, 2000), and Krau Wildlife Reserve in Pahang (Sirka and Josh, 2002).

The Department of Wildlife and National Park (DWNP), Peninsular Malaysia has conducted an intensive survey on the distribution of fauna around Malaysia from year 1992 until now. This record is very important to study the distribution pattern of *R.bicolor* around Malaysia in order to formulate the good conservation plans for them in the future.

Apart from studying *R.bicolor* itself, several studies have also been conducted on *R.affinis, R.indica* and *R.macroura* in Malaysia and around the world. Only *R.bicolor* and *R.affinis* occur in Malaysia. As well as *R.bicolor*, there have also not been many researches conducted on *R.affinis* in Malaysia. The few studies on *R.affinis* were mainly on their distribution and behaviour.

Together with *R.bicolor*, the distribution of *R.affinis* was recorded during surveys conducted by DWNP, Peninsular Malaysia from 1992 until now, and by several groups of researchers, such as at Ulu Endau Johor (Davinson and Heang, 1987), Pasoh Forest Reserve Negeri Sembilan (Kemper, 1988), Temenggor Forest Reserve Perak (Ratnam *et al.*, 1995), Tasik Chini Nature Reserve Pahang (Lim *et al.*, 1999), Belum Forest Reserve Perak (Norsham *et al.*, 2000), Pulong Tau National

Park Sarawak (Shanahan *et al*., 2000), Krau Wildlife Reserve Pahang (Sirka and Josh, 2002), and Lambir Hills National Park Sarawak (Shanahan and Debski, 2002).

On the other hand, there are many studies conducted on *R.indica* in India mainly because this species is widely distributed across the Indian range. All the studies carried out intensively on distribution, morphology, behavior, threats and conservation plan of *R.indica* (Ramachandran (1988), Borges (1990), Borges (1993), Umapathy and Kumar (2000), Sushma and Singh (2006) and Srinivas *et al.,* (2008).

In India, the giant squirrels (*Ratufa indica*) are known as generalists animals because they have wide ecological amplitude and are known to increase in density in moderately disturbed forest. The density of *Ratufa indica* increased with decreasing area and increasing disturbance level. This is caused by two reasons, firstly, this squirrel is a widely distributed species also occurring in other vegetation types such as moist and dry deciduous forests and with a relatively small home range (13.38 ha in moist deciduous forest) (Ramachandran, 1988) and feeds on a variety of plant species and parts (Ramachandran, 1988 and Borges, 1993). Second reason is that interspecific competition can play an important role in deciding the relative abundance of species that have overlapping resources needs, especially in forest fragments (Kozakiewicz, 1993).

Apart from the surveys mentioned above, there are several studies that have been conducted on ecology, density, trends, conservation status of the *R.macroura* in India, such as by Ramachandran (1988), Joshua (1992), Paulraj and Kasinathan

(1993), Joshua and Johnsingh (1994) and Kumar *et al*., (2007). Only one study related to *R.macroura* that was conducted by Maryanto *et al*., (2001) in Indonesia on survey on mammals in different land use types.

In summary, most of the *R.bicolor* studies in Malaysia, as mentioned above, only focused on their distribution and morphology characteristics. Detailed studies on giant squirrels have been conducted intensively in India. Their researches are a significant contribution towards understanding the ecology and behavior of *R.bicolor*. It is hoped that better understanding of the complexity of *R.bicolor* behavior in different habitat characteristics will be attained.

2.3 Previous research conducted in Penang Island

There is lack of information and no comprehensive study has been done about flora and fauna in Penang Island except for the purpose of education research by lecturers and students, as well as by group of naturalists, such as Universiti Sains Malaysia, Malaysia Nature Society, Forestry Department of Peninsular Malaysia and DWNP, Peninsular Malaysia. All the researches were conducted mainly at Penang National Park.

Penang National Park is located on the northwest of Penang Island, at 5^{o} 28'N, 100^{o}12'E. The area covers approximately 1265 ha of primarily coastal hill dipterocarp forest, coastal mangrove forest, sandy beaches and rocky shores. Part of the area has been logged up to 1962 but the activities were stopped in the early 70s. Although a small portion has been logged, the area is still substantially intact, including a pristine virgin jungle about 80 ha. It contains a variety of shore habitats

ranging from rocky outcrops and sandy beaches to estuarine flats at the mouths of streams. This small area provided a suitable habitat for a rich diversity of birds, mammals, reptilians, and amphibians.

An intensive study of the diversity of birds, mammals, reptilians, and amphibians in Penang National Park by Malaysia Nature Society (MNS) together with Universiti Sains Malaysia was carried out from early July 1997 until 2006 (Shahrul and Ibrahim, 2006). The animal life in the park comprise 31 species of mammals, 128 species of birds, 44 species of reptiles and 20 species of amphibians (Shahrul and Ibrahim, 2006).

The coastal forest of Penang National Park is one of the significant features in the area. The influence of seawater and coastal weather has relatively created a unique characteristic of the forest inhabitants, especially the flora and fauna (Chan *et al.,* 2003). The flora corresponds closely to the vegetation of Peninsular Malaysia, and consists of coastal mangrove ecosystem, lowland dipterocarp forest and some hill dipterocarp forest including medicinal species to ferns, palms, pitcher plants, meromatic flora, climbers and fungi.

The main families species in the dipterocarp forest are Dipterocarpaceae, Leguminosae, Apocynaceae, Burseraceae, Dillenaceae and Palmae. Herbaceous plants include Araceae, Marantaceae, Gesnariaceae, Zingiberaceae and Commelinaceae. Commercial plants species listed here are Balau (*Shorea materials*), Seraya (*Shorea curtisii*), Meranti (*Shorea* sp.), Resak (*Hopea* sp.) and Damar Laut. Another common tree is the fig tree belonging to the family Moraceae

(Chan *et al*, 2003). Small patches of mangrove do occur along shores of Pantai Acheh village, estuaries of Sungai Tukun, riverbank of Sungai Telok, and Pantai Mas. Mangrove vegetation here is dominated by *Avicennia-Sonneratia* and *Rhizophora-Bruguiera* forests (Shaida *et al*., 2003).

More than that, Penang National Park is also a habitat for some protected and endangered species such as, black giant squirrel, flying lemur, green turtles and more. These species have been listed as totally protected species under the Malaysian Wildlife Conservation Act (2010) and also classified and protected under the international law. In the Penang Island, Penang National Park provided the best harborage for these species with it tall forest and ample breeding areas (Ibrahim & Shahrul, 2004).

2.4 Environmental problems in Penang Island that affect the distribution of the Black Giant Squirrel (*Ratufa bicolor*)

In Malaysia, the rapid changes in the natural environment were mainly caused by the continued eco-social growth and industrialization whereby the coastal area is the most affected region. The coastal zone of Malaysia, especially Penang, experience the most intense human activity, where a large percentage of the population, ports, industries, tourism constructions, as well as agriculture, fisheries, mineral, communication, transportation, recreation and sewage discharge have resulted in many conflicting human activities on this island (Chan *et al.,* 1998).

Penang state has the highest population density in Malaysia with 2,031.74 people per square kilometer on the island and 865.99 people per square kilometer on the mainland (Chan *et al.*, 2003). The high density of human population of Penang Island has put pressure on the land. Therefore, Penang has developed very rapidly over the last 30 or more years (Chan *et al.*, 2003). Much of flat plain in Penang, especially on the east part is now silvicultural area, agricultural area or heavily logged to satisfy needs of the people and raise the standards of their lives. The situation has become worse nowadays when the development processes are encroaching into hills and much of coastal areas in Penang.

As such, developers have turned to the remaining hill land on the island. Many hills and their surrounding are already being developed and many hill projects are in the pipe line such as along Batu Feringghi. This has led to many environmental problems, such as deforestation, decimation of water catchments, destruction of endangered fauna and flora, soil erosion, landslides, water pollution, sedimentation and downstream flooding.

Some of these problems have been exacerbated and turned into disasters due to the extremely fragile and sensitive nature of hill ecosystems. Despite such problems, the State Government has decided to lift the freeze on development of hill land since January 1998, and this has effectively opened up all hill land for development on the island.

All developing activities could have caused decreasing numbers of *R.bicolor* in Penang Island. For example, most of the *R.bicolor* nesting trees, such as

Casuarina equisetifolia have been cleared along the beach to fulfill tourism needs without concern for the Squirrels' habitat requirement. More than that, deforestation is also seriously causing *R.bicolor* to lose their food sources and safe nesting locations.

2.5 Conservations plan for the Black Giant Squirrel (*Ratufa bicolor*)

Deforestation is of great interest in understanding the loss of biodiversity, soil degradation and water cycling (Zhang *et* al, 2005). Losing habitat due to the habitat destruction and the decreasing of the species number continue to rise all over the world. Nowdays, the importance of biodiversity conservation is widely recognized, as there is a general concern about its currents status and about the responses by society to present and future environmental changes (Euridice *et* al., 2007).

Protected areas are essentials elements of the strategies of modern societies to ensure the resourses are used sustainably and biodiversity is conserved for present and future generations. One major objective of national parks besides the aim to protect and further enhance biodiversity (species, ecosystem and landscape diversity), is to promote the education, health, aesthetic values and recreation of the people (National Parks Act, 2006).

The general approaches of protected area are as a biodiversity conserve and education place to learn nature. But before louncing public awareness campaigns and conservations projects, it is necessary to first focus on a better understanding of the species by doing more research and study. Although Malaysia tropical rain forest

offers such a wide range of flora and fauna, lake of studies on their habitat distribution and requirement could effect their survival in the future. So, it is important to stress that management and conservation plans can be success for only with scientific knowledge on each flora and fauna, as a foundation.

In order to achieve long term solutions to environmental problems, education should be deliberately incorporated into educational programs for protected areas. Environmental education is one method to promote low impact at recreational activities. It is an important concept in enhancing the publics' awareness on natural resources and forestry issues. With awareness, natural resources will be more appreciated and the public can play a role in conservation. Thus, impact from recreational use would be reduced as the burden is shared between the managers and the users.

The establishment and management of protected areas are an alternative way for conserving biodiversity in tropical Asia (Jeffrey, 2008). Until now, Malaysian Government has gazetted more than 10% of the land area as legally protected areas. The multiple benefits of the protected area include to provide a wide range of social, culture, recreation, and scientific values.

The sustainable use and management and conservation of environment are keys to maintain human economics activity and well-being. Sustainability implies maintaining components of the natural environment, such as biological diversity, water quality, preventing soil degradation over time, while simultaneously maintaining and improving human need. There are three interacting components

required for successful natural resource and environmental management, namely policy, participation and information (Koprowski, 2005).

In Penang Island, 17% of it lands is now gazetted as protected area including as national park, forest reserve, state park and recreation area. Most of the protected areas are mainly upland area, and also function as water catchments areas (Malaysian Nature Society, 1999).

Under the National Park Act No. 226 of 1980, Pantai Acheh Forest Reserve was established as a national park. From then it was known as Penang National Park and under the management of the Department of Wildlife and National Parks, Malaysia (PERHILITAN) (Shahrul and Ibrahim, 2006). Although, PERHILITAN was the principal agency in the management of the Penang National Park, it is also supported by several direct agencies, such as Department of Fisheries, Department of Forestry, and Department of Environment (DWNP, 2008a).

These relevant agencies all have a role to play in ensuring that the development of the national park and its surrounding areas are in line with the need to conserve Penang's biodiversity. The Penang National Park is the first park to be established under National Parks Act, 1980 (Chan *et al*., 2003). Section 4 of the Act states the object of the establishment of the park is the preservation and protection of wildlife, plant life and objects of geological, archeological, historical and ethnological and other scientific and scenic interest and through their conservation and utilization to promote the education, health, aesthetic values and recreation of the people (DWNP, 2008a).

CHAPTER THREE
STUDY AREA

3.1 Scope of study

This study was conducted from January 2008 to December 2009. Generally, this study was carried out in two phases. The first phase was fieldwork (site sampling) procedure which was carried from January 2008 to June 2009. The second phase was carried out in the laboratory by analysing the data colleted during field work. The second phase was done from July to December 2009.

3.2 Description of study area

3.2.1 Climate, topography and habitat types

Penang is a state in Malaysia, located on the northwest coast of Peninsular Malaysia and the second smallest state in Malaysia after Perlis. Penang Island (Figure 3.1) is an island of 299.65 km^2 located in the Straits of Malacca.

Penang Island is irregularly shaped, with granite, hilly and mostly forested interior. About 50% of the island is hilly, over 60 m in elevation with slopes between 25^o and 30^o. The central backbone of Penang Island is higher toward the northern part, while the flat plain can be found at the east and west of Penang Island. The highest point is Western Hill (part of Penang Hill) at an elevation of 830 m a.s.l above sea level. The coastal plains are narrow, the most extensive of which is in the northeast, which forms a triangular promontory where George Town, the state capital, is situated (Chan *et al*., 2003).